DIGITAL QUALIFICATION PROCESS MANUAL

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ABSTRACT: This Qualification Manual sets the guidelines on product qualification to be followed by all Product Management Teams and Qualification Teams, spanning the breadth of Digital's product offering from components to systems, including clusters and distributed systems. This manual also formalizes a process for qualifying buyout and value engineered products.

APPLICABILITY: This document applies to all products and services marketed by Digital Equipment Corporation, including new products designed and manufactured by Digital or Digital's suppliers, and value engineered products manufactured by Digital or Digital's suppliers.

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1 INTRODUCTION

1.1 PURPOSE

This document unifies Manufacturing, Customer Services, Hardware Engineering, Software Engineering, Product Management, Program Management, and Quality into two teams that manage a consistent qualification process across Digital. The two teams are Product Management and Qualification.

This document shows how to develop and implement a qualification plan, provides the teams with methods for qualifying to product requirements, and identifies, defines, and clarifies responsibilities.

Quantifiable discrete steps for analysis and improving functionality, time-to-market, reliability, cost, and all of the other product quality requirements intended to ensure customer satisfaction are also provided.

1.2 SCOPE

Products for qualification are applicable to new products manufactured by Digital or by Digital's suppliers, and ECOed and value engineered products manufactured by Digital or by Digital's suppliers.

Products include the following.

- IC components
- Non-IC components
- Hardware systems, subsystems, subassemblies, accessories, and supplies
- Software operating systems and layered products
- Distributed systems

1.3 PRODUCT MANAGEMENT TEAM

The Product Management Team is (as defined in *DEC STD 028-0 Phase Review Policy* draft Rev. B, subhead 4.3) composed of, but not limited to, representatives from the following functional groups: Engineering, Finance, Manufacturing, Marketing, Sales and Customer Services. This team ensures that all product quality requirements are met.

The team is expected to comply with the guidelines outlined in DEC STD 028-0 and other corporate policies, such as those developed by the Pricing and Announcement Committee (PAC). For qualification, their activities and responsibilities include the following.

- Establish the Qualification Team (refer to subhead 1.4), and designate the members.
- Provide a schedule and prioritized information to the Qualification Team, prototype material, and other required resources for the successful implementation of the qualification process.
- Receive qualification information and risk assessments from the Qualification Team, and provide inputs, feedback, and guidance back to the Qualification Team.

The Product Management Team must have consistent membership from Phase 0 through Phase 4b.

1.4 QUALIFICATION TEAM

The Qualification Team is a cross-functional team responsible for planning and implementing the total qualification test program for a new product.

This team must have consistent membership from Phase 0 to Phase 4b.

This team includes one member from each of the organizations represented on the Product Management Team. Members must have the authority to act on behalf of the organizations they represent. The members will solely have the right to vote. Other, non-voting members are selected from the following groups.

- Reliability Engineering
- Product Assurance/Quality Assurance Engineering
- Design Engineering
- Manufacturing Quality Engineering
- Customer Service System Engineering
- Software/System Engineering

The Qualification Team can use resources from any organization within Digital to ensure the success of the program. At the request of voting members, additional individuals or organizations may be added to the team as consultants.

This team manages the planning, testing, analysis, and reporting for each testing procedure, which includes the following.

- Review and approve each plan before testing begins
- Review periodic summaries of test data
- Determine and review the classification of failures
- Review plans for corrective action on failures
- Determine test status
- Determine test termination (halt or successful completion)
- Assess and document risks to facilitate decision making
- Establish a unified data collection system for all problem reporting

1.4.1 Formation of the Qualification Team

The Qualification Team is formed during Phase 0 of the Phase Review Process. The Engineering Development Manager is responsible for calling together the Product Management Team to identify the Qualification Team members. The Product Management Team is responsible for reviewing and approving all proposed Qualification Team members.

1.4.2 Qualification of Team Members

The following criteria has been established to ensure a team of qualified members is chosen.

Product Knowledge

- Knowledgeable about the product or able to acquire that knowledge quickly.
- Understand the customer's environment.

- Understand qualification methods and equipment relative to their effectiveness in the qualification test process.
- Technically conversant with Design Engineering, Manufacturing and/or Field Service counterparts on the product.

Reliability

- Understand designing for reliability, including the following.

— Specification of goals
— Modeling
— Reliability prediction techniques
— Control of raw materials
— Part control programs
— Design reviews
— Worst case timing analysis
— Thermal management techniques

- Able to read into the "design" customer needs and be able to influence the design to meet those needs.
- Technically conversant with reliability concepts and models, and their implications.
- Understand software reliability and its relationship to system reliability.

Communication and Interpersonal Skills

- Oral and written communication skills, and articulate with authority on the needs and goals of the organization he/she represents.
- Understand and support the charter and goals of the Qualification Team.
- Presents issues clearly.
- Persuade others without being abrasive.
- Has a good understanding of the disciplines he/she represents.

Understanding of the Qualification Process

- Understands and follows prescribed disciplines, such as the Phase Review Plan, the qualification of product to specification, and so forth.
- Understands the total qualification test process.
- Recognizes proper test disciplines or lack of them, understands the associated risks, and knows how to deal with the situation.
- Has the authority to make technical decisions without approval from upper management, and has good understanding of business consequences.
- Familiar with the process of resolving problems, and with its implication on overall product goodness.
- Determines when to escalate an issue to upper management. It is important to identify alternative resolutions with risks and benefits stated for each.

1.5 Chairmanship

It is important that the Qualification Team has an established chairperson. This position may rotate. The following rotation is suggested, but the final decision is up to the team.

- Product assurance during design and human factors analysis and testing.
- Reliability engineering during reliability evaluation and testing.
- Manufacturing during manufacturing process evaluation and testing.
- Customer Services Systems Engineering during field and customer evaluation and testing, maintainability, and human factors testing.

1.5.1 Voting Criteria

At the conclusion of the various phases of testing (RQT, DVT, and so forth), the Qualification Team must formally vote to complete each test. The members of the Qualification Team, each representing the functions specified in DEC STD 028-0 are the only people to participate in the voting. Decisions will be unanimous.

1.6 MANAGEMENT EXCEPTION AND ESCALATION PROCESS

One of the responsibilities of the Qualification Team is to report status, risk assessments, and recommendations to the Product Management Team on a periodic and timely basis. In the event that the Qualification Team does not agree on a course of action or the risk assessment as related to one of the product quality requirements, both opinions must be presented in writing with alternative solutions listed to the Product Management Team.

1.7 QUALIFICATION PROCESS REQUIREMENTS

The following are the requirements of the Qualification Process.

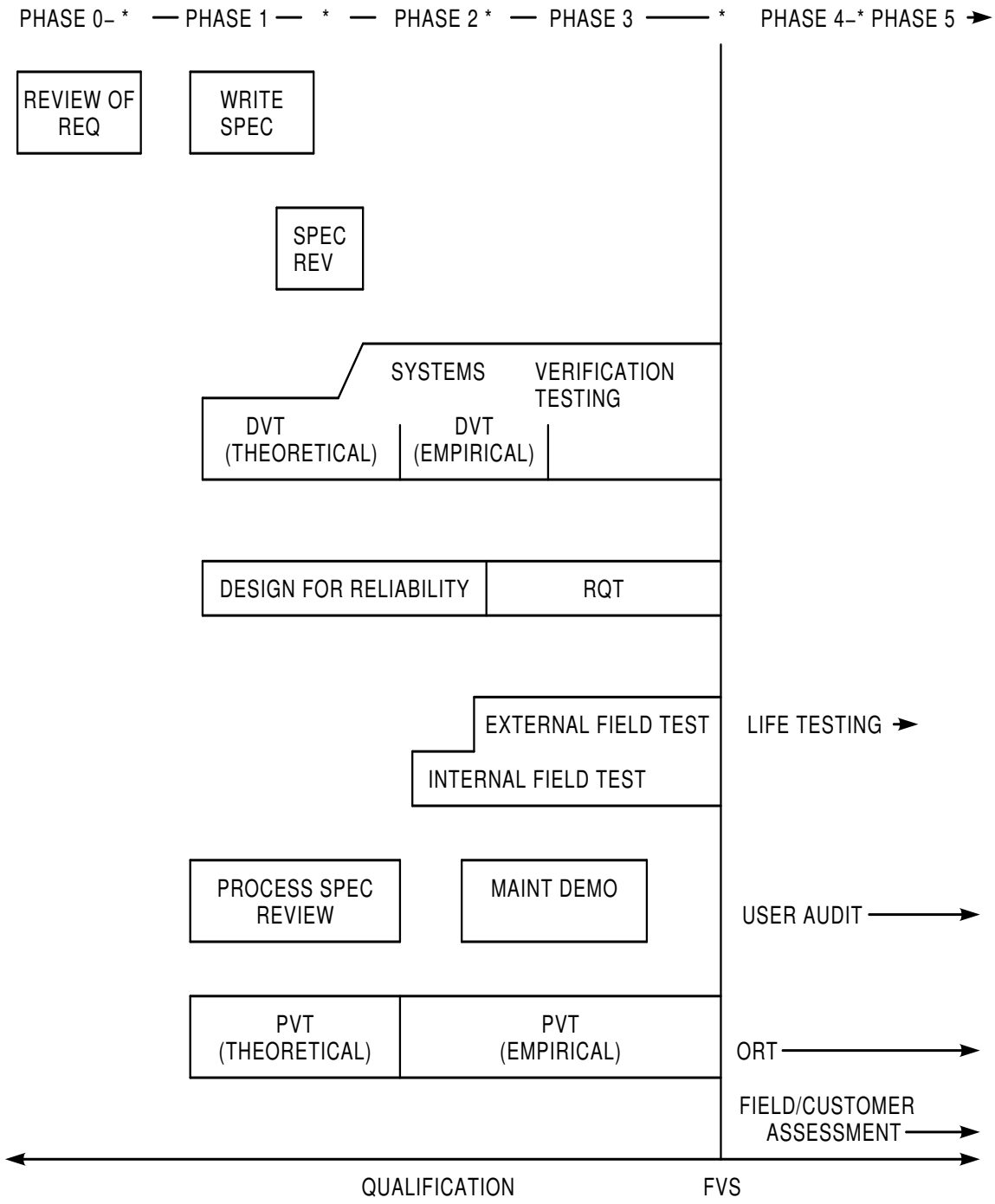
- Product quality requirements that are based on competitive market analysis and customer needs and expectations, including the following.
- Specifications are approved at all levels (IC components, non-IC components, hardware systems and subassemblies, software operating systems and layered products, distributed systems) by key functions (Engineering Development, Field Service, Manufacturing, Product Manager, Program Manager, Quality, Software).
- New product functionality is thoroughly examined and verified.
- Applicable Digital standards are met.
- Product reliability is verified at all levels (IC components, non-IC components, Hardware systems and subassemblies, software operating systems and layered products, distributed systems).
- Manufacturing process goals and metrics are met.
- Manufacturing process can consistently produce a product that meets its specifications (functionality, parametric, Digital standards, regression tests for Engineering Change Orders (ECOs), and reliability).
- Product is verified to meet or exceed competitive market requirements, and it is verified by customers to meet or exceed their expectations.

- Qualification is linked to the Phase Review Process such that well- defined milestones are met prior to each phase transition. Similarly, key qualification milestones, required by PAC for announcement and First Revenue Shipments (FRS) of new products, are met.
- A formal management exception and escalation process is defined to be used if any of the above items have not been completed as required.

1.8 QUALIFICATION PROCESS FLOW DIAGRAM

The diagram on the following page is a summary of the major Qualification Process Activities. The diagram captures most of the major milestones, along with their relationships to each other and the phase review process as described in the rest of this document. The intent of the diagram is to provide users with the sequence of events and the relative timing of the various qualification activities with each other and the phase review policy.

Figure 1: Qualification Process Flow



2 PRODUCT QUALIFICATION PROCESS

This heading sets the guidelines on product qualification to be followed by all Product Management and Qualification Teams spanning the breadth of Digital's product offering from components to systems, including clusters and distributed systems. This heading also formalizes a process for qualifying "Buyout" product and a process for qualifying value engineered products. The entire heading emphasizes "what needs to be done" and leaves the detailed "how to" procedures to individual product teams.

NOTE

This heading covers all products except those originated in storage and information management group (LES DRAMS). Due to the nature of their product set, storage and information have developed their own qualification process. That document appears as EL-EN522-01. The differences between the approved RAC process and storage systems will continue to be worked. It is our aim to have a single document in the future.

2.1 NEW COMPONENT (IC AND NON-IC) QUALIFICATION PROCESS

IC Standard A-SP-210000GS-15
Non-IC Standard, T.B.D.

2.2 NEW HARDWARE QUALIFICATION PROCESS

2.2.1 Product Attribute Definitions

Cost - Cost has two aspects, cost to Digital, and cost of ownership to customers. Cost to Digital is Digital's investment to develop, deliver, and maintain the product. Cost of ownership to customers is the customers' investment to purchase, operate, and maintain the product.

Capabilities - Features and functions of the product.

Compatibility - The ability of all components (hardware and software) to work together to form a stable system within the Digital network environment. It is the ability of spares to work with the system without modification to the system, and to integrate new components (versions, models) into the system without disturbing system stability. It is the ability of software to work across members of the system family.

Installability - The ability to install and make operational all components of the system (hardware and software) using the information provided by Digital within the expected length of time and with the expected degree of ease.

Usability - This covers the human factors aspects of product design. It relates to the ease with which a customer can learn how to use the product, interact with it, and perform user-intended tasks.

Reliability - The probability that the product will perform its intended functions without failure in a specified environment over a specified period of time. MTBF (Mean Time Between Failures) is commonly used to define reliability, but it must be remembered that this is only true in such cases (or periods of the products life cycle) where the failure rate of the product or system can be assumed to be constant.

Availability - To Be Determined.

Dependability - To Be Determined.

Maintainability - A characteristic of the design and installation which is expressed as the probability that a product or system will be returned to specified operating condition within a given period of time when maintenance actions are performed in accordance with prescribed procedures and resources.

Manufacturability - The characteristic of a product that describes the ease and economy of manufacture of the design.

3 SPECIFICATION REVIEW

This activity ensures that a formal and proper review of all the applicable specifications for the new product is accomplished prior to the start of qualification testing.

The new product qualification team is responsible for arranging and conducting the specification(s) review.

The following guidelines apply to all products, including systems, subsystems, and subassemblies.

3.1 PREREQUISITES

The Qualification Team is in place and functioning. All new products require a product specification, including the reliability requirements specified in this document. Prior to the specification review, therefore, prior to Empirical Design Verification Testing (DVT), all applicable specifications must be under document control (Preliminary Change Order/Engineering Change Order/Manufacturing Change Order).

In addition, the following key documents must be complete at this point.

- Business Plan - Phase 1
- Functional Specification
- Project Plan
- Manufacturing Plan
- Customer Services Plan (preliminary)
- Market Requirements Document
- Product Requirements Document

3.2 COMPLETION CRITERIA

The results of this review, as it pertains to the readiness of the new hardware product to enter the qualification stage, is passed on to the Product Management Team with a written recommendation. The determination of the new product's readiness to begin testing is the qualification team's responsibility; that is, all specifications are under document control, and they are complete and accurate.

3.3 FINAL REPORT

The final report is a written recommendation from the Qualification Team to the Product Management Team, stating that the Qualification Team has reviewed all applicable specifications and has deemed them complete and accurate.

3.4 DESIGN FOR RELIABILITY

This subhead stresses the importance of designing for high product reliability. Since the inherent reliability of a product is a function of its design, there needs to be a strategy in place to ensure that product reliability goals are met or exceeded as a part of the product development cycle. The best way to do this is to set clear reliability goals prior to product development and use all available design for reliability techniques in order to meet that goal.

Design For Reliability is an activity that should be practiced on all products covering the range of product offerings (components, software, systems, networks).

Stress derating, improved cooling techniques, and redundancy are techniques for improving the reliability of a design.

Rather than try to go into all of the methods of sound design for reliability practices, it is suggested that each product development team member, and qualification team member gain a thorough understanding of designing for reliability and explore the different methods that can lead to higher product reliability on their respective products.

A "Systems and Networks Reliability Design Process" has been published by the Reliability Advisory Committee for use as a starting point and reference material.

4 DESIGN VERIFICATION TESTING (DVT)

The design verification process is different for the many types of products Digital produces. It requires design verification techniques that are tailored to the development methodologies and technologies in use, and that are geared to uncovering the types of flaws or weaknesses that are common to the specific type of design or product. In general, the philosophy of DVT is: If you said it will do it, and it is in the specification, it will be verified during DVT.

This heading presents guidelines for the development of a comprehensive DVT plan and outlines tests which, where applicable, shall be executed and successfully completed.

DVT ensures that:

- The design is complies with specified functionality.
- The design team adheres to good design practice as specified by the quality and reliability functions within the development PBU. The intent is that designers will know what is expected so that DVT is passed quickly with few problems discovered: that components are verified (functionality and reliability understood) before starting option DVTs, or before starting system or network verification tests.
- The design is ready for the Reliability Qualification Test.
- The design complies with all applicable Digital standards.

4.1 PREREQUISITES

The major prerequisites to a DVT are:

- System level, FRU level, and component level specifications.
- For operating systems new functions or releases: Test, Diagnosis, and Error Handling Specifications. (Refer to Frank Robbins' Guide to Error Handling Specification.)
- Component functionality proven before start of option/sub-assembly DVT and option/sub-assembly proven before system/network DVT.
- The reliability program plan for the project.
- Requirements document.
- DVT plan approved by the Qualification Team.
- All documentation, including but not limited to the following, is required for the theoretical portion.

— Preliminary parts lists

— Flow diagrams

— Equations

— Timing diagrams

— Schematics

— Access to the design data base

— Tolerance studies

— Cross talk

— Signal integrity

- The most important prerequisite is to have enough well-trained design and design verification engineers and technicians to complete all tasks, and assist design engineers in correcting all problems uncovered, within schedule.
- A predetermined number of prototypes or pilots must be available on time, with adequate test equipment, test beds, and chambers.
- The Quality, Reliability, and/or Design Assurance group in each PBU must establish quantitative standards of excellence and acceptance for measurement in areas such as, but not limited to, the following:
  - — Crosstalk less than or equal to some specified amount.
  - — Signal return noise less than xxxx mv on a backplane, xxx mv on VCC and return pins of ICs, and less than xxx mv from any point to any other point with at least yy random points measured.
  - — Junction temperatures all less than or equal to specified values.
  - — All capacitive voltage stresses less than xx percent of rating.
  - — Other quality and reliability specifications of what is considered adequate derating, margining, worst case design techniques.

— Requirements found in: *DEC STD 009-1 Product Engineering Specifications: Electrical, Physical, and Environmental Parameters*; EL-SM012-00, *Digital Part and Documentation Identification Standards Manual*; EL-EN505-00, *Signal Integrity (SI) Rules Design Guide for CAD*; and EL-ENPCD-TM, *Electrical Design Guide for Printed Circuits*.

DVT

DVT is one discrete test with definable steps and completion criteria. Some of the steps of DVT are done before prototypes are built (for example, simulation), while others are done using prototype or pilot production units (for example, thermal margin verification). Although DVT should be thought of as one discrete test (separate, for example, from RQT or ORT), it is suggested as good practice to report on subsections as they are completed. The following subsections are considered by this document as parts of DVT and are required.

- A theoretical review
- An empirical set of tests on prototype or pilot hardware
- Digital standards testing
- Diagnosis and Error Handling Verification
- Systems Compatibility Verification

The following sections on theoretical and empirical DVT focus on verification of hardware and any embedded code required to meet the functional product specification only.

Each Program Management Team ensures that a detailed and thorough DVT plan is created during Phase 1. The DVT plan should include, where applicable, the following elements.

Major changes in the design or specification of the product during DVT may call for a complete update of the plan, schedule, and budget.

Theoretical DVT

Documentation review - familiarize, understand, and compare all relevant project documentation. The review includes, but is not limited to, the following:

— Compare the engineering specifications to the requirements of all applicable Digital standards and legal requirements.

— Requirements document(s)

— Detailed system requirements documents for multi-system peripherals and terminals.

— Documentation plans review

— Schematic review, equations, flows, and other applicable design documentation

— Diagnosis and error handling plan review

— Reliability plan review

— Project plan review

— Part/technology choices review

— Preliminary timing review

— Possible layout considerations review

— Software interface specifications
— Firmware specifications
— Overall product specification

Part List Analysis

— Qualification status and vendor selection
— Parts stress analysis (including thermal)
— Maximum use of integration
— Misapplication of parts, family compatibility of parts

- Layout check for opens, shorts, extra etch, power and return connections, DEC STD 030 compliance.
- Layout rule check (DEC STD 186-0 Signal Integrity)
- Electrical loading check of all ICs, discrete circuits and components, and I/O ports.
- Review of Design Automation output to ensure design meets all Design Automation rules.
- THUDS analysis (Automated Thermal Simulation Analysis).
- Theoretical analysis of effects of humidity, altitude, vibration, shock, hazardous chemicals, and electrostatic, electromagnetic, and magnetic fields.
- Mechanical tolerance build up analysis, dissimilar metals, ease of assembly, fitness for use, manufacturability.
- Logic and circuit simulation.
- Automated worst case timing analysis.
- Manual worst case time analysis (sanity check on automatic analysis) especially for metastable conditions, asynchronous hazards, critical circuits, major cycles and areas of layout concern, clock speed sensitivity, and input/output busses.
- Analysis of power and signal distribution.
- Analysis of power allocation and consumption.
- Analysis of testability and maintainability aspects of the design.
- Analysis of international features and labels required.
- Creation of test microcode to margin the hardware.
- Verification of firmware, module by module, manually or automatically or both.
- Verification of diagnostic coverage, usefulness to user, and effectiveness.
- Conformance to safety requirements, including flame retardation and avoidance of use of toxic substances (DEC STD 119).
- Proper airflow, cabling workmanship, acoustics, ease of use.
- System error recovery.

Empirical DVT

- Layout check (continuity, DEC STD 030, DEC STD 186).
- Tolerance study.

- Acoustic analysis.
- Power connections check.
- Power consumption check.
- Power sequencing check.
- Corrosion tests.
- Verify temperature and voltage rules obeyed where applicable.
- Loadable test directed diagnostic coverage, effectiveness, and ease of use verification, ease of system level fault isolation, error logging, and symptom directed diagnosis.
- Effects of temperature extremes on media.
- Boot, on-board diagnostics, microcode/firmware verification to specification evaluation
- Mechanical integrity.
- Signal intensity degradation over time.
- Compliance with manufacturing assembly and test procedures, ease of manufacture.
- ESD susceptibility.
- All operator functions validated.
- All device specific parameter tolerances verified.
- Power supply regulation.
- Print quality.
- Wear characteristics.
- Shmoo (Voltage and temperature margining to fail points).
- Differential signal return and VCC noise measurements.
- Power up/down cycling and proper response.
- Clock variation test.
- Signal integrity verification under all interface conditions (for example, cables at one an a half maximum specified length).
- Video geometry, focus, linearity, light output, and so forth.
- Empirical thermal analysis (for example, infrared scans, thermocouple, air flow transducers, and so forth).
- Module capacitance measurement at all busses internal and I/O.
- Functionality Testing: Timing, all software and hardware selectable features and functions tested. Special consideration should be given to the test and qualification of new critical components, interfaces of new technology to old technologies, and so forth.
- Crosstalk measurement.
- Electrical loading tests at I/O ports margined to fail points.
- Conformance to all applicable bus specifications by simulation, hand, and logic analyzer including power up/down.

- Architecture verification: Running Architecture Exerciser (AXE), Prism Architecture Exerciser (PAX), Multi-Architecture Exerciser (MAX), and other architecture stressing programs and workloads.
- Interchangeability: Chip for chip, different vendors, module slot for module slot, media/drive for media/drive, write hot read cold, and so forth.
- System Compatibility: All system components communicate effectively without inducing degradation in the operation of another component.

Digital Standard Testing

Compliance to the various applicable DEC Standards should be included in DVT. They include the following:

- Verification of compliance with DEC Standards 102, 103, 104, 119 (Product Safety), and 178.
- Verification of Compliance where applicable with DEC Standards 002-0, 005, 009, 030, 032, 038, 052, 053, 057, 060, 062, 120, 122, 123, 158, 160, 166, 186, and any other applicable DEC Standards. Refer to EL-SMDEX-00, EL-Class Document Directory.

Diagnosis and Error Handling Verification

Using all necessary empirical and automated tools, verify compliance to the diagnosis and error handling specification.

Such things as fit, tolerance build up, ease of manufacture, compatibility with other standard system components, and compliance of the component to Digital standards when in the intended systems environment as well as speed/performance as specified in the systems environment are validated in this step.

Recommended Tools In addition to those tools noted throughout subhead 2.2.3:

- The DVT must use supported and consistent test tools, test all major deliverables separately and initially in the smallest possible blocks, and then in combination for system level tests.
- Simulation is perhaps the most important, and therefore highly recommended part of DVT. It has been mandated in many parts of the company. As time progresses, automation and integration into the design process of nearly all DVT steps may be proper and beneficial.
- For empirical DVT, many sophisticated tools are required for thorough and accurate work. Although too numerous to list completely, such tools include the following.
  - — Shmoo plotters
  - — Logic analyzers
  - — Simulation systems
  - — Differential preamplifiers
  - — Walk in and reach in chambers
  - — Effective diagnosis tools and processes

Completion Criteria

- Completion comes in stages. Completion of the theoretical portion is achieved when all steps in the theoretical portion of the plan have been completed successfully and documented.
- Completion of empirical tests is also achieved after all appropriate steps in the DVT plan have been completed successfully, properly documented, and required waivers, if any, secured including a plan in place to clear the waivers.
- Required waivers for unresolved or outstanding issues in the DVT shall be secured according to the requirements of DEC STD 066-2.

For Reporting, see subhead 2.2.9.

5 Maintainability Verification Test (MVT)

These guidelines are intended to aid consistency in the development of Maintainability Verification Testing across products. The Maintainability Verification Test is the first opportunity to test the product's maintainability attributes, supporting tools, documentation, training and service processes together. Since it is performed at a time when the pressure to ship the product is very high, it is imperative that this testing be well-planned and executed.

These guidelines provide consistency in the planning and execution of Maintainability Verification Testing.

The goal of Maintainability Verification Testing (MVT) is to ensure that everything necessary to maintain and support the product in the field environment is ready and has come together successfully. Specifically, the service delivery process and its supporting tools and documentation are to be validated against the Field Implementation Plan, recovery plans for incomplete elements may become necessary in limited cases. In order to conduct a successful MVT certain prerequisites must be met, guidelines for these will be given here, however specifics will vary by product.

5.1 PREREQUISITES

The Qualification Team is normally sponsored by the development group. Representatives from all the major contributing groups are included, guidelines for its membership will be found in other parts of the qualification document.

The Customer Services Team is normally be comprised of representatives from the following groups:

Department	Function
CSSE, Customer Services Systems Engineering	Maintainability Engineering Project Management. Owners of the MVT.
Field Service Areas (Including Customer Support Centers (CSCs))	Service Delivery Implementers
ASDS	Advanced Service Delivery Systems

Department	Function
Field Service Logistics	Material deployment and repair
Educational Services Development and Planning	Documentation and training
Diagnostic Engineering	Diagnosis tools

Each of these groups has deliverables to the maintainability program and the Maintainability Verification Test.

5.1.1 Plans and Specifications

Early in Phase 0 of the project, as defined in DEC STD 028-0, plans must be made to ensure that the necessary tasks are defined, funded, scheduled and staffed. Of necessity there will be interdependence, particularly in the areas of Design Verification Testing (DVT), Maintainability Verification Testing (MVT) and Field Test. The following list of plans and specifications is recommended as a minimum, others may be required according to the product and project needs:

Plans

- The maintainability program plan for the project.
- MVT plan; approved by the qualification team.
- DVT plan; with sections addressing verification of the maintainability attributes of the design. An item of particular concern is the dynamic fault insertion test plan. This must detail the processes by which errors will be dynamically inserted into the product in order to verify fault handling from detection to FRU isolation.
- Field Implementation Plan; describing call handling and escalation procedures, training, documentation and design support needs.
- Training Plan; describing the courses to be developed for each level of field support.
- Documentation Plan; detailing in particular the field and support maintenance manual and print sets.
- Logistics Plan; detailing the distribution of spares, return procedures, repair processes, strategies for handling multiple pulls and NPFs.

Thorough review of these plans is required in order to ensure that interdependencies and expectations are clear, and commitments are firm.

Specifications

- System, sub-system, FRU, and component level fault handling specifications. The system level specification should be thought of as architectural, the lower levels as constructional.
- Maintainability/Serviceability requirements document. This may also be referred to as the Maintainability Design Specification in these guidelines.
- Service process specification. This must describe service activity, tools usage and call handling procedures for each of the anticipated failure modes.

Prerequisites to Start the MVT

The major prerequisites to a MVT are the following:

Prerequisite Testing - The maintainability engineering section of the design verification test must be completed successfully.

Supporting Documentation - All documentation, including but not limited to the following, is required in at least draft form:

- Flow diagrams, including error flow and recovery attempt paths.
- Timing diagrams, including error detection timing and its relevance to the consumption of bad data.
- Schematics
- Fault matrices, CAD and/or manually derived.
- Access to the design data base
- Diagnostic Users' Guide
- Fault Isolation Manual
- Maintenance Manual
- Field Call flow scenarios for each of the anticipated major failure modes. These form the basis of service delivery verification as a function of failure type.

Service processes

- Primary and support service processes in place. Note that it may sometimes be necessary to emulate or redirect the actual support service in order to avoid automatic escalation within the operational field service call handling process.

Tools

- Diagnostics; Symptom and Test Directed, Built in Self Test, Boot and Load checks, ROM based, and so forth.
- Fault list. Note that the chosen faults should be distributed in a manner similar to the predicted failure rate distribution within the product.
- Statistical Validity of faults chosen. It will be necessary to choose a statistically valid sample size for each of the anticipated failure modes and syndromes or symptom sets. Some guidance on determining sample sizes and determining the validity of results can be found in the Maintainability Demonstration Test Guide section of the CSSE process book. It should be noted that the set of 200 faults referred to in that document may be invalid when divided into many sub groups.
- Bad parts. Some of these may be taken from the manufacturing line if they are believed show symptoms similar to what will be experienced in the field. Process induced faults, such as shorted and open etch, should not normally be used for MVT. Consideration should be given to introducing intermittent faults which can be aggravated by timing or voltage margins, the goal being to verify the correct use of this technique. This might be achieved, for example, by the judicious addition of small capacitors to clock or data lines.
- Remote service response software.

People

- An adequate number of trained field service engineers and technicians to complete all the tasks.
- Observer, to record actions taken, time and parts consumed, this role will normally be performed by a CSSE engineer.

5.1.2 MVT Testing

Test Environment

The Maintainability Verification Test itself is to be devoted to verifying the compatibility and completeness of the following elements in the service delivery context.

Product Maintainability Attributes

Typically these will include hardware error detection and recovery mechanisms, micro and macro code error logging and retry capability. These will have been verified in DVT, the purpose here is to verify their usage in the service context.

Service Call Handling Processes

The call handling processes will already exist, the purpose here is to verify that failure types are recognized correctly and cause the proper actions (i.e., escalation) to be taken.

Post Training Job Skills

Verify abilities to use diagnosis and fault isolation tools correctly and to follow the repair process flows.

Test and Diagnostic Processes

These will have been verified from a technical aspect in earlier testing, specifically in DVT. MVT will be directed more at verifying their ergonomics in the service environment.

Supporting Documentation and Tools

The documentation will have already been reviewed for technical accuracy and its ability to support the training programs. MVT of this element is aimed at verifying its value in the service process.

To this end a laboratory situation should be set up as follows:

- On site —Only the tools which are planned to be available to the first on site person. Included in the on site tools would be any auto diagnose, self test, or automatic service call generating hardware and software. People trained to first on site level. Documentation as defined in the Field Implementation Plan.
- Off site — Off site tools, documentation and individuals trained to off site levels. Any automated call handling processes must be in place, some "trap vectors" may have to be plugged to escalate calls to the appropriate CSSE group, or discontinue further escalation in order to avoid confusion in the automated outage system. Access to design data bases where these are considered essential to the support function (usually). Access to operating system and diagnostic source code listings. Access to micro code source listings. Much of this will be incorporated into, or accessed through, the Customer Support Center Information System. Part of the CSC team member's task will be to generate the necessary data bases and to obtain access to other data bases.

- NOTE: None of the above presupposes where the first fault isolation attempts will be made from (i.e., remotely, on-site automatically, by site visit). It merely states that the laboratory environment should be set up to resemble the field and customer environments as closely as is practical.
- Observers - Fault lists, bad parts as appropriate, service process flows, alignment and adjustment procedures where appropriate, note pad or forms for recording and timing each service event and consumption of materials.

5.1.3 MVT Testing

The MVT testing will consist of the observer inserting faults in the product and having the first level of fault isolation attempt to isolate the fault and initiate repair. Information on the paths actually followed (predicted ahead of time for each fault class), the time taken, tools used, parts consumed, and so forth, should be noted by the observer AS THE ACTION TAKES PLACE ! Note that some fault types may be emulated merely by the generation of error log entries from some installed process (i.e., the dynamic fault verifying software). It will not always be necessary to physically insert actual faults.

The responsible CSSE group must determine and accept responsibility for the actual parameters to be measured, since these will vary by product type, service need and service delivery method. These will typically include, but not be limited to the following:

- Repair and replacement times.
- Material consumption per repair.
- Ease of physical repair and replacement.
- Diagnosis and isolation times.
- Percentage of problems escalated to each level of support.
- Call handling scenario flows.

The relative importance of these parameters will vary by product, market need and the chosen maintenance approach.

5.1.4 Results and Reporting

Organization of Results

An MVT failure is defined as any discrepancy between the actual maintenance activity that takes place and that which was planned or predicted. Failure results should be organized by functional groups responsible for their correction. The design of "Observers' forms" can help considerably in this regard by providing check boxes to indicate if the failure was due to shortcomings in, for example, the documentation, training, diagnostics, material availability, escalation processes, or any other service process failure.

Recovery Plans

In the unlikely event of MVT failure, recovery plans must be made and implemented as soon as possible. Any decisions to not support the product, or to support only a very limited volume of shipments until its maintainability is improved should be considered at this time. In the case of very significant failures it may be necessary to abandon the MVT and restart when the underlying causes have been corrected.

Subsequent Testing

The Maintainability Verification Test itself is only the first phase of Maintainability Verification. The verification continues throughout the products' life as service delivery continues to evolve and the product reaches maturity. Some of the later phases are noted below, it is beyond the scope of these guidelines to describe them fully.

In-House Prototypes

A program should also be put in place to gather data from InDec field service in their support of prototype, pilot and other preproduction units. This provides the closest representation of the field environment at the earliest opportunity.

Field Test

This can be thought of as a continuation of the MVT and In house prototype support activity measurements. Complexity is added due to the remoteness of the installations and the learning curves of all the supporting tools and processes. The field test plan will address this phase in much greater detail, for MVT purposes it should be thought of as an ongoing verification which is now out of the laboratory.

On-going Field Measurements

This is the final transition to "operational status". Plans must be made to phase in at least a sample population in order that steady state field behavior can be observed and controlled, as well as the impact of ECO and FCO improvements.

6 Reliability Qualification Test (RQT)

The Reliability Qualification Test is the portion of the qualification process established to verify that the proposed product or system meets the reliability portion of the engineering specification. It is the responsibility of the qualification team to develop and implement the RQT plan, while the product management team is responsible for approving the plan.

In addition to verifying that the reliability specification is met, the RQT has the following secondary purposes:

- Estimate with acceptable precision the infant mortality and steady state reliability parameters.
- Evaluate the effectiveness of infancy reduction procedures (i.e., burn-in or other stress screens) at the component, module, and/or system levels.
- Feedback to design engineering, manufacturing, and CSSE.

6.1 PREREQUISITES

In order to proceed with the RQT, there are three basic prerequisites. First, the design and specification must be complete (what we test is what we intend to ship). Second, the RQT plan must be complete and approved by the product management team. The third prerequisite is that all prior qualification testing (see heading 2) verified that the product meets all functional and performance characteristics detailed in the engineering specification.

Basic RQT Requirements

The RQT is intended to demonstrate the reliability of the final design prior to full revenue production. As such it is neither a test-analyze-fix effort nor a reliability growth exercise. Units that are committed to RQT shall be expected to perform as they would had they been shipped to the field and employed in a typical customer configuration.

Test Sample Size and Test Length

Test units should be produced by the manufacturing process(es). All component qualification has been completed and intended infancy reduction processes have been applied to the units so that the expected ship performance and failure rates will be realized. The RQT sample size and test length are a function of the following parameters:

- Specified failure rate and MTBF
- Discrimination failure rate and MTBF
- Confidence level (percent)
- Discrimination ratio (specified MTBF/discrimination MTBF)
- Precision factor (estimated MTBF/lower confidence limit MTBF)

The test sample size and total test time per unit are chosen to satisfy the test precision requirements and to allow for adequate discrimination between estimated failure rate (at one thousand hours) and MTBF (at ten thousand hours) and the corresponding discrimination failure rate and MTBF values. A software tool for use with the NHPP demonstration model is available for determining test sample size and total test time per unit requirements.

Prediction Model

The recommended model for reliability predictions combines a decreasing-failure-rate Weibull model for the infant mortality period of operation, with a constant-failure-rate exponential model for the steady state. A software tool entitled Computer-Aided Design Reliability Engineering (CADRE) is available to automate reliability predictions for this model.

Demonstration Model

The Non-Homogeneous-Poisson-Process (NHPP) with Weibull intensity function is the recommended model for conducting reliability demonstrations: it allows for decreasing, constant, and increasing failure rates. The CENSOR software tool is available for analysis of reliability data for non-repairable systems. The NHPP software tool is available for NHPP analysis of reliability data for repairable systems. The NHPP tool is based on a model that assumes that at the time of repair, the repaired system failure rate equals the system failure rate just prior to the repair. This assumption is reasonable when the repaired assembly failure rate represents a small percentage of the overall system failure rate. The RENEWAL PROCESS software tool is available for analysis of reliability data for repairable systems, where the repaired system failure rate at the time of repair is much different from the system failure rate just prior to the repair. Note that the CENSOR and RENEWAL PROCESS tools offer a wide variety of time-to-failure distributions (Weibull, log-normal, exponential, and so forth) for statistical data analysis.

Risk

Risk must be addressed prior to demonstration. The risk referred to here is the risk of making an incorrect decision relative to the reliability of the product based on the results of testing. The measure of risk used in RQT is the confidence level (numerical risk = 1 minus confidence level). Typically, a confidence level range of seventy to ninety percent is considered for the RQT, where the incremental benefits of a higher confidence level (reduced risk) must be weighed against sample size and test length considerations. The confidence level chosen for the test is a business decision.

Given the confidence level, a confidence interval is determined from the NHPP statistical reliability data analysis. A two-sided confidence interval is expressed in terms of a lower confidence limit (LCL) and an upper confidence limit (UCL). A single-sided confidence limit is expressed in terms of one limit; the LCL for steady state MTBF estimation or the UCL for infant mortality failure rate estimation. For example, with an eighty percent confidence level for MTBF, the data analysis will yield an eighty percent LCL. The interpretation of the LCL is that we are eighty percent confident that the MTBF for the test sample exceeds the LCL value. A similar interpretation applies for an eighty percent UCL for infant mortality failure rate.

Test Strategy

The test sample and test length for the RQT are described in heading 2. At various intervals defined in the RQT plan, interim data analyses should be performed to determine if the product or system under test is on track for passing the test. The results of these interim analyses should be reviewed in detail by the qualification team and reported in summary form to the product management team.

When the test sample has been tested for the specified test length, the data analysis is used to determine whether the product or system meets the requirements in the RQT plan (see Diagram 1). The infant mortality reliability decision is based on the UCL failure rate for the first thousand hours against the infant mortality discrimination failure rate (see Diagram 2). The steady state reliability decision is based on the lower confidence limit of the projected reliability at steady state against the discrimination steady state MTBF (see Diagram 3). It is generally a requirement that a minimum of three data points be observed before the precision and discrimination requirements of the test can be met. If fewer than three data points are observed, the Qualification Team may decide to use a different decision making process. (A Bayesian extension of the NHPP Demonstration Model, Heading 2 is under development specifically as a decision framework for tests generating fewer than three data points.)

The Qualification Team then provides the product management team with one of the following recommendations:

- Product or system passes RQT.
- Product or system requires additional testing in RQT; the length of this testing is specified in the Qualification Team recommendation.
- Product or system fails RQT.

The final RQT report is published summarizing all test results and recommendations.

It is the Product Management Team's responsibility to make the product decisions taking into account the Qualification Team recommendations and other business considerations.

The test strategy must be designed to demonstrate that the product or system meets both the infant mortality and the steady state reliability specifications.

There are any number of other considerations to be dealt with regarding test strategy:

- All failures during RQT are analyzed until the root cause can be isolated. Failures that count against the infant mortality and steady state reliability requirements occur after the product or system under test is proven to be functional. Failures that occur during the first pass of diagnostics, UETP, or application software are recorded as Dead-On-Arrivals (DOAs). The first occurrence of a failure that cannot be confirmed such as an intermittent, transient or software related defect count against the acceptance criteria for this test. The second occurrence or subsequent failures of an identical nature are recorded but do not count against the pass/fail criteria. All software failures and intermittent and transient hardware failures are recorded as part of the crash rate and availability metrics. Ultimately, the intent in RQT is to include crash rate and availability in the acceptance criteria, but this requires the development of predictive crash rate models and empirical validation of these models.
- The product (options, systems, and so forth) must be complete units, as they would be installed at the customer's site. If it is a board level option, it must be installed in the intended receiving equipment. If it is a system, it must be configured as specified (including expected peripherals).
- Diagnostics/software: Diagnostics may be run during the RQT, but they must not be the sole exerciser. Applications software and UETP shall be used as to the greatest extent feasible. The intent should be to fully exercise the product during test.

Test Environment

The test environment should be described in the RQT plan. The appropriate acceleration factors should be applied when the test environment differs from the environment given in the reliability portion of the engineering specification.

The RQT Plan

An initial RQT plan is a Phase 1 exit requirement for the product or system. The final RQT plan must be agreed to by the qualification team and approved by the product management team prior to the start of the RQT. As a minimum it must contain the following sections:

- The test team composition and responsibilities.
- The Reliability Requirements Section.
  - — The infant mortality failure rate specification (i.e., failures in the first thousand hours of operation).
  - — The steady state MTBF specification (i.e., MTBF after ten thousand hours of operation).
  - — The reference environment for the reliability specification.
- The statistical test description.
  - — Test sample size.
  - — Test length (number of hours per unit on test).
  - — Test confidence level.
  - — Discrimination failure rate and MTBF.

  - — Test Strategy.
  - — Acceptance criteria.
- The sample and test specifics/procedures.
  - — Test bed setup.
  - — Test environment.
  - — Operator/technician procedures.
  - — Test software/diagnostics, and so forth.
- The method of collecting data.
  - — Information to be collected.
  - — How information will be collected.
  - — Controls to ensure proper documentation.
- The method of failure data analysis.
  - — Failure analysis procedures.
  - — Data analysis procedures.
- The definition of a failure.
  - — Countable failures and actions required.
  - — Non-countable failures and actions required.
- The completion criteria.
  - — Qualification team recommendation with supporting report/data.
  - — Product management team decision.
- The frequency and content of interim and final reports.

7 Process Verification Testing (PVT)

The process verification test is an assessment of the manufacturing process as defined by the product manufacturing plan, prior to volume build.

PVT verifies that the manufacturing process (including each step) is capable of producing a product that meets or exceeds all of its goals and specifications for yield (cosmetic and functional), standard time, infancy, steady state reliability and customer satisfaction.

The Process Verification Test applies to any introduction or transfer of new systems, subsystems and subassemblies. A Process Verification Test may also be implemented for major ECOs of a product or significant process changes.

The Manufacturing plant chartered to build the system/subsystem/subassembly shall develop the PVT plan in conjunction with and the approval of the Product Qualification Team. Typically, the organization within manufacturing that is specifically responsible for the development and management of the plan is either the Manufacturing Engineering Organization or the Quality Assurance Organization. Generally, a team is formed within manufacturing to focus the PVT process and includes various engineering, quality, materials and production representatives. The plan is then submitted to the Product Management Team for approval.

7.1 PVT THEORETICAL PRODUCT/PROCESS REVIEW PREREQUISITES

Before this first step (theoretical process review) in the PVT process is begun, the following should be available and ready for review:

Process Design

- Preliminary process specification and/or manufacturing plan
- First pass of the PVT Plan
- Preliminary procedures and process sheets
- Process capability and volume sensitivity analysis

Process/Product Test

- Manufacturability analysis of the design
- Test diagnostic evaluation and coverage

Infancy Model and Reduction Process

- Proposed component screens and failure rate models
- Capital equipment and training requirements

PVT Theoretical Product/Process Review

A theoretical review of the product and process is completed by an independent manufacturing team before any units are built. The purpose of this review is to verify that all goals related to yield (cosmetic and functional), standard time, infancy, steady state reliability and customer satisfaction have been quantified, documented and agreed to.

The evaluation of each of the proposed process steps is completed to optimize the process layout before final commitments are made to capital and human resources.

PVT Build Verification Prerequisites

Before any production units enter the process, a cross-functional review is completed to assure that the following activities have been completed:

- PVT Theoretical Product/Process Review completed
- PVT Plan documented and approved by the Manufacturing Team, Product Qualification Team and the Program Management Team and available to all participants
- Manufacturing Plan or Process Specification detailing the product and process steps (inclusive of all goals) documented, signed off and available to all participants
- Personnel product and process training completed
- Process sheets, procedures and appropriate documentation signed off and available at each process step
- Data collection forms and visual aids available for each step
- Fault insertion testing completed to evaluate test and diagnostic coverage for each test step in the process
- Revision control (REVCON) for products, assemblies and subassemblies available and current

- Review of component qualification status, risks and approved vendors (QVLs)
- Review of controlled components listing and status of all regulatory and safety certifications and labeling process
- Review of the reliability specification and model and progress during RQT testing
- Tools for assembly and test are available and calibrated
- Design Verification Testing (DVT) is sufficiently complete to minimize risk due to major design changes and ECOs

PVT Build Verify

An initial production run is completed to measure, correlate and demonstrate that the goals for each process step can be met. Corrective action is documented and agreed to where necessary before any volume can be built beyond the PVT sample. The sample size for PVT is dependent on the available time, process goals, infancy and steady state reliability specifications that have been established for the systems, subsystems, and/or subassemblies.

PVT Infancy/Steady State Reliability Assessment

As a part of the Build Verify process of PVT, the units are also run through the proposed infancy reduction process(es). Appropriate acceleration factors are used to normalize the results to the environment at which the design was specified and demonstrated in RQT. If the process is a burn-in test, the units are run for a sufficient period of time (i.e. generally a minimum of 500 hours) to establish the infancy profile of the population with adequate confidence to determine the time required to meet the infancy specification that was established (i.e. failures in the first 1000 hours at the customer site). The secondary purpose of this test is to demonstrate that the reliability requirement at steady state (10,000 hours) can be met with sufficient and specified confidence to recommend first shipment to the customer. The demonstration model, decision making process, methodology and tools are described in heading 2.

Data Requirements and Analysis

Data will be collected and analyzed in all steps of the process as defined in the PVT and Manufacturing Plans. Actual performance will be measured against the previously established goals and specifications and any deviations will be documented and addressed. Where actual performance is below goal or specification, appropriate corrective actions will be implemented. The data obtained will be used as a base line for process control charts and future process capability studies.

Failures

All failures during PVT are analyzed until root cause can be isolated. Failures are recorded against the infancy and steady state reliability specifications that were demonstrated in the RQT. All confirmed process related infancy and process induced reliability degradation count against the pass/fail criteria established for the test. The first occurrence of a failure that cannot be confirmed such as an intermittent, transient or software related defect count against the acceptance criteria for this test. The second occurrence or subsequent failures of an identical nature are recorded as part of the crash rate and availability metrics but do not count against the pass/fail criteria. In general, a failure is any event that can be recognized at a customer site and/or would result in a call to field service (inclusive of software). Failures that count against infancy and steady state reliability goals occur after the system, subsystem or subassembly is proven to be functional. Failures that occur during

the first pass of a diagnostic, UETP or application software are assumed to be "time 0" failures and generally count against the Dead-On-Arrival (DOA) goals.

Although many of these failures cannot currently be modeled and included in the expected failure distribution, it is always manufacturing's goal to assemble and test the products in an environment that has no negative effects on inherent failure rates. Each process (Stage 0, I, II, III) is expected to optimize their infancy reduction processes within their facilities so that they can ship to their customers products that meet their individual goals for infancy.

Completion Criteria

The Qualification Team and the Product Management Team must approve the final report and agree that the following criteria, as a minimum, have been met:

- The parameters of all process steps have been documented and measured and the goals and specifications have been achieved (or the process specifications have been changed)
- All corrective actions are in place
- The infancy reduction process has been optimized and verified to yield a product that meets its goals for infancy
- The initial reliability assessment conducted during PVT has verified that the manufacturing process is capable of yielding a product that meets the infancy and steady state reliability specifications.

Reporting

Interim reports are published after the results of the Theoretical Product/Process Review, Build Verify and Infancy/Steady State Reliability Assessment. The Final PVT report is published summarizing all test results and recommendations for additional testing and first shipment within two weeks of PVT conclusion.

8 ON-GOING RELIABILITY TEST (ORT)

On-going Reliability Testing ensures that the product produced in manufacturing continues to meet its specifications for infancy and steady state reliability.

The requirements in this section apply to all Digital manufacturing facilities.

The Plant Quality Assurance organization develops the ORT plan in conjunction with the Product Qualification Team. The plan is then submitted to the Product Qualification Team and Program Management Team for approval before implementation by the Plant Quality Assurance organization.

8.1 PREREQUISITES

The following prerequisites must be met before ORT is initiated in Manufacturing:

- Product/System/Subsystem/Subassembly specifications are released and contain infancy and steady state reliability requirements
- All systems/subsystems/subassemblies affected by these guidelines have successfully completed the following tests inclusive of final reports:
  - — Design Verification Testing (DVT)
  - — Operating System Certification

  - — DEC Standards Testing
  - — Regulatory Agency Testing
  - — Systems Evaluation Engineering Testing and/or network certification
  - — Reliability Qualification Testing (RQT)
  - — Process Verification Testing (PVT)
- The ORT plan and procedure have been approved
- Test diagnostics, UETP and any application software have been analyzed for coverage and are under release control
- The ORT team is identified and chartered to implement the plan
- ORT units are randomly selected from the manufacturing process

Manufacturing ORT Team Membership

While it is the responsibility of the Product Qualification Team to ensure that an effective ORT process is in place, it is key that the manufacturing facility have a team focused on the day to day management of ORT. That team should consist of individuals from the following organizations in the plant:

- Plant Reliability Group
- Production
- Quality Assurance
- Manufacturing Engineering

Others will participate as required/requested by the team for support.

Test Environment

To the greatest extent possible, the customer's environment should be simulated. Following is a list of considerations that should be addressed and documented in the ORT Plan:

- Environment
- Product Duty Cycle
- Power On/Off Cycling
- Voltage
- Software
- Configurations/Interchangeability

Sample Size/Selection and Test Goals

The sample size and test length are a function of the first five of the following parameters, all of which must be specified in the ORT Plan:

- Specified failure rate and MTBF
- Discrimination Failure Rate and MTBF
- Confidence level (percent)
- Discrimination ratio (specified MTBF/discrimination MTBF)
- Precision factor (estimated MTBF/lower confidence level MTBF)

- Failures in the first 1000 hours at the customer site

The sample size and total test time per unit are chosen to satisfy the test precision requirements and to allow for adequate discrimination between estimated failure rate (@1000 hours) and steady state MTBF and the discrimination failure rate and discrimination MTBF values. A software tool for use with the NHPP demonstration model is available for determining test sample size and total test time per unit. In general, a minimum of 500 hours of runtime are required for each unit under test. If the test requires 16 units per month, each week four new units would be added to ORT and the four oldest units would be removed. If ten units were required monthly, three new units would be added one week, followed by two new units the following three weeks.

Demonstration Model

The Non-Homogeneous-Poisson Process (NHPP) with Weibull intensity function is the recommended model for conducting reliability demonstrations during ORT. The CENSOR software tool is available for analysis of reliability data for non-repairable systems. The NHPP software tool is available for analysis of reliability data for repairable systems. The NHPP tool is based on a model that assumes that at the time of repair, the repaired system failure rate equals the system failure rate just prior to the repair. This assumption is reasonable when the repaired assembly failure rate represents a small percentage of the overall system failure rate. The RENEWAL PROCESS software tool is available for analysis of reliability data for repairable systems, where the repaired system failure rate at the time of repair is much different from the system failure rate just prior to the repair. Note that the CENSOR and RENEWAL PROCESS tools offer a wide variety of time-to-failure distributions (Weibull, log-normal, exponential, and so forth) for statistical analysis.

Risk

The measure of risk selected for ORT is the risk of making an incorrect decision relative to the reliability of the product based on the results of testing. In general, the risk selected for ORT should be the same level as that selected for RQT (recommended range of 70% - 90%). The benefits associated with a greater confidence level in the decision must be weighed against the additional samples required and/or greater test time required. See heading 2 for additional discussion on risk.

Decision Process

A decision is made with each ORT sample as to whether it is meeting its reliability requirements for infancy and steady state MTBF (see Diagram 1). The infancy decision is based on the upper confidence limit of the failure rate for the first 1,000 hours against the discrimination failure rate (see Diagram 2). The steady state reliability decision is based on the lower confidence limit of the estimated reliability at steady state against the discrimination MTBF (see Diagram 3). If the ORT sample is not meeting its infancy goals as specified, additional test time or various infancy reduction processes should be implemented in the process to enable goals to be met. It is generally a requirement that a minimum of three data points be observed before the precision and discrimination requirements of the test can be met. If fewer than three data points are observed, the ORT Team may decide to use a different decision making process or combine two ORT samples.

Failures

All failures during ORT are analyzed until root cause can be isolated. Failures are recorded against the infancy and steady state reliability requirements that were demonstrated in the RQT and PVT. All confirmed failures including process related infancy and process induced reliability degradation count against the pass/fail criteria established for the test. The first occurrence of a failure that cannot be confirmed such as an intermittent, transient or software related defect count against the acceptance criteria for this test. The second occurrence or subsequent failures of an identical nature are recorded as a part of the crash rate and availability metrics but do not count against the pass/fail criteria. In general, a failure is any event that can be recognized at a customer site and/or would result in a call to field service (inclusive of software). Failures that count against infancy and steady state reliability specifications occur after the system, subsystem or subassembly is proven to be functional. Failures that occur during the first pass of a diagnostic, UETP or application software are assumed to be "time 0" failures and generally count against the Dead-On-Arrival (DOA) goals.

Performance Below Goal

The ORT plan should clearly outline the steps to be taken if the demonstrated steady state reliability or infancy for the product does not meet specified requirements.

Reporting

A summary of the ORT results for a system/subsystem/subassembly will be issued monthly by the Plant Quality Assurance Group.

Figure 2: Empirical Failure Rate Curve

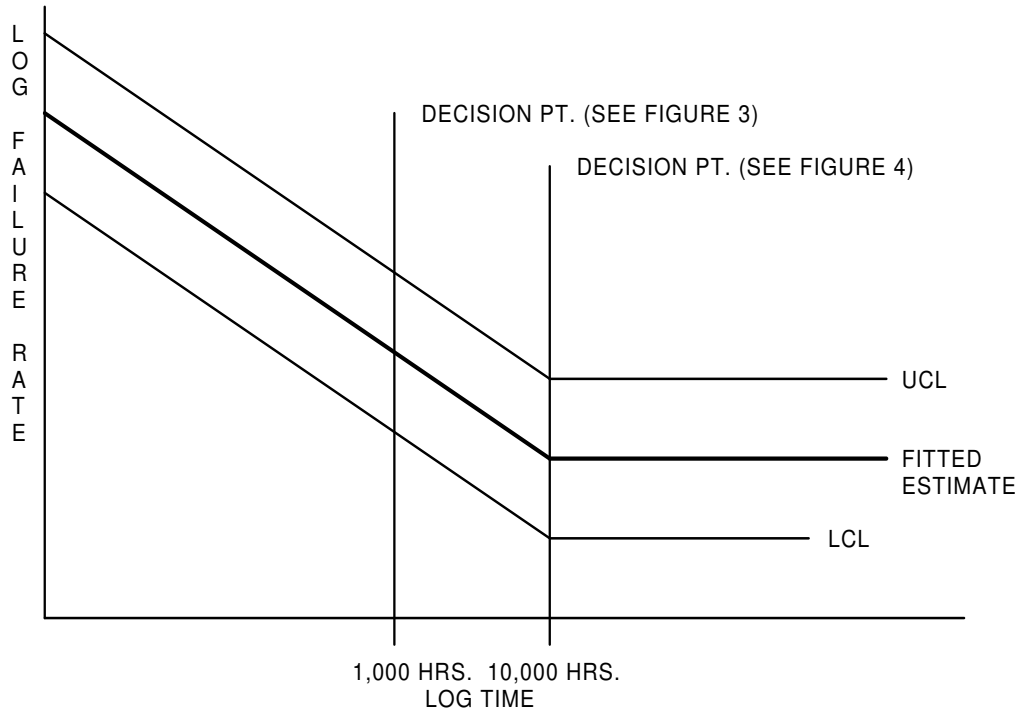
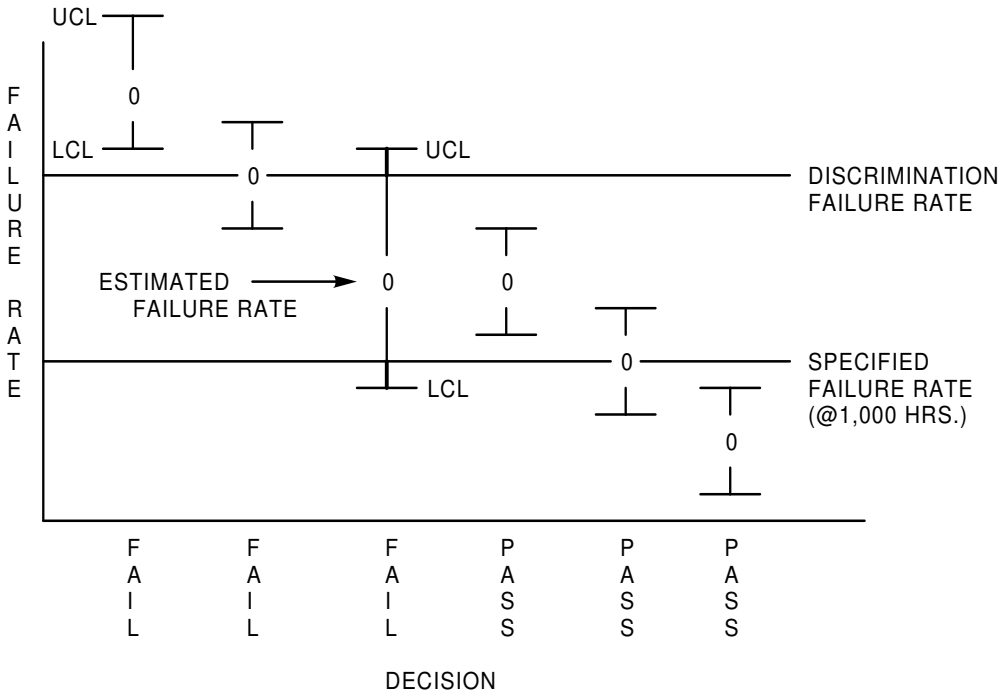
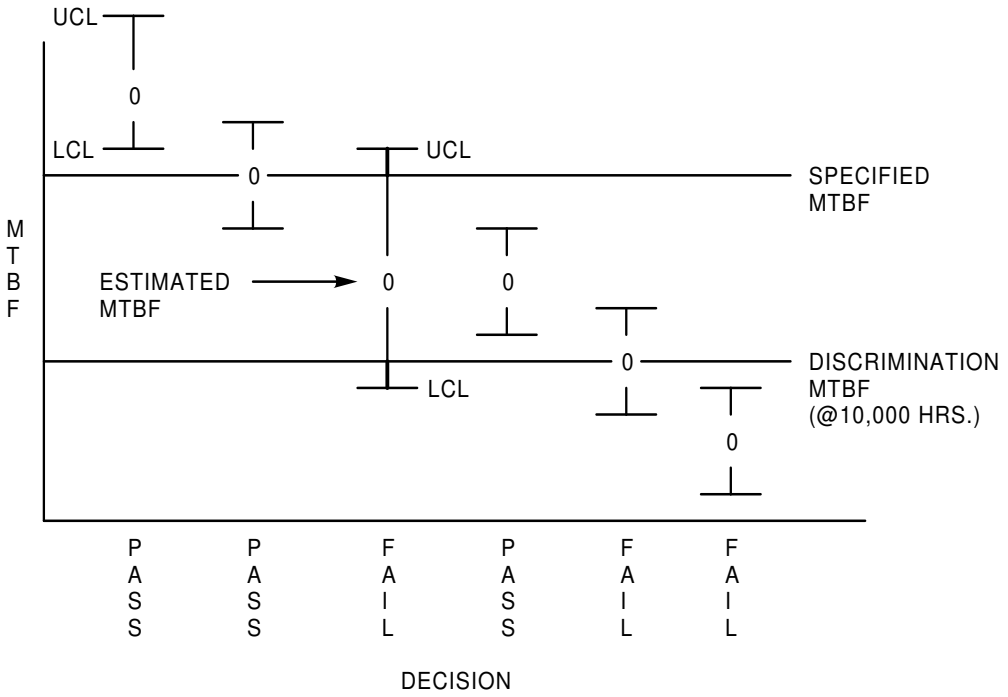


Figure 3: Decision Map - 1,000 Hr. Decision Point



DECISION MAP FOR THE SIX POSSIBLE OUTCOMES
AT THE 1,000 HR. DECISION POINT IN FIGURE 2

Figure 4: Decision Map - 10,000 Hr. Decision Point



DECISION MAP FOR THE SIX POSSIBLE OUTCOMES
AT THE 10,000 HR. DECISION POINT IN FIGURE 2

9 FIELD TEST

Field test is a key milestone in the Phase Review Process. This outline provides a set of guidelines that form the nucleus of Field Test process, linking into the overall qualification process, including reliability.

The primary objective of a field test is to provide a rigorously controlled dry run for FRS, particularly to obtain information about the product deficiencies or potential problems which were not discovered during previous testing. The basic objectives of field test are to:

- Verify that the product functions according to specifications in a customer environment.
- Verify the adequacy, usability, completeness and accuracy of the product documentation.
- Verify that general performance goals are met.
- Verify that human engineering factors are accomplished.
- Verify the accuracy of the installation procedures and verify that the product is customer installable, if applicable.
- Identify as many product and process deficiencies or omissions as possible within the customer environment.
- Verify that diagnostics and diagnostic procedures are adequate.

- Verify that the ease of use and customer satisfaction metrics have been met.
- Identify and correct any serviceability deficiencies which may be encountered.

Kinds of Field Test

There are two kinds of field test normally conducted, Alpha or Beta.

Alpha Tests take place at internal test sites, and start after products meet a predetermined level of functional performance during DVT. This field test is optional for all new products. Beta Tests take place at external field test sites, and should start after functionality is verified through DVT and design meets all criteria for entry into RQT. This field test is required on all new products and major design/functional changes.

Description

- Field Test Planning —Schedule all factors and activities affecting Field Test. Set criteria for entry and exit, and license agreement.
- Selection — Use the criteria defined under subhead 2.2.9.4 to determine the best qualified sites.
- Site Planning and Preparation —Schedule all factors and activities affecting the site. Refer to subhead 2.2.9.6.
- Install product and then resolve all problems that are found.
- Terminate Field Test when all exit criteria have been met.

Groups Involved

- Development Engineering, Product Management, CSSE, User Documentation, Field Test Support, Product Assurance, Manufacturing, Sales, Product Marketing and field service. Field Test Support may be defined as a Field Test Administrator or any person designated to provide administrative and logistical support for the field test team.

Field Test Plan

Product Management with inputs from all involved groups, is responsible for producing the Field Test Plan giving the following information.

- Product/Program overview.
- Field Test objectives.
- Field test start criteria.
- Field test exit criteria.
- Prerequisite hardware and software, including documentation.
- Recommended number of sites.
- Criteria for site selection.
- Scheduling and major milestones.
- Field test support.
- List of members of the field test team.
- Responsibilities of field test team during field test.
- Problem reporting and resolution process.

- List of potential field test sites.

The Field Test Team reviews and approves the Field Test Plan. The Field Test Team consist of Product Management, Development Engineering, CSSE, User Documentation and Field Test Support.

Entry Criteria

Alpha Test - The following criteria must be met:

- Functional specification signed off.
- Specified DVT milestones have been met.
- Documentation functionally complete (draft).

Beta Test - The following criteria must be met:

- The product must include full functionality.
- Documentation available.
- Should start after functionality has been verified through DVT and design meets all criteria for entry into RQT.
- Fully supported by Field Service.
- To start beta testing, 50% of installations must be up and running.

Completion Criteria

- FRS version of hardware, firmware, and software must be successfully be installed and operational at some of the Field Test sites.
- All problems reported during Field Test have been closed to the satisfaction of the Field Test Team.
- Documentation has been thoroughly reviewed.
- All sites have been polled for final comments.

Legal Considerations

The legal considerations for preparing Field Test site plans and for conducting tests are to be followed. Contact the legal department for specific information.

Site Selection

- All communications are DIGITAL CONFIDENTIAL.
- Product Manager formally announces the upcoming Field Test, and requests nominations for test sites.
- For non-Digital sites first contact with prospective Field Test sites is made by local account management team. For Digital sites, this can be done by Engineering.
- The Field Test Team makes final selection after reviewing nominations' surveys.

Site Qualifications

Alpha Test Sites

- Normally, internal engineering environment (applications software development, and so forth).

Beta Test Sites

- All parties in agreement to Field Test.
- Site must sign the Field Test License Agreement.
- Must meet the required hardware and software configuration.
- Must commit to test every component or reasonable configuration of product in accordance with the Site Test Plan (Hardware products).
- Must be able to tolerate crashes.
- Must agree to evaluate the product, respond to surveys, questionnaires and report all problems in the agreed manner.
- Must not be a problem account.
- Must return all field test materials.

Site Planning

- Preparing the site plan is the joint responsibility of Engineering, the Field Test Support person and the Field Test Site and field service
- Plan provides the following information:

— Detailed description of product to be tested

— Field test objectives

— Intended usage and configuration

— Responsibilities of Field Test site

— Problem reporting/resolution plan

— Equipment list

— Field test schedules - start and end dates

— Installation information

— Description of support

— Spares information

— Verification that local field service agrees to the field test schedule (via a signature block for local field service manager)

9.1 RESPONSIBILITIES

Product Manager

- Periodic reviews to discuss status.
- Secure site list for field test selection process.
- Participate in the selection Beta Test sites.

- Ensure coordination of field test activities.
- Translate the field test experience/feedback into future product requirements.

Engineering

- Prepare units for test including spares.
- Participate the selection Beta Test sites.
- Provide support for problem resolution.
- Ensure resolution of all problem reports in a timely manner.
- Repair and/or replenish consumed spares.

Documentation Group

- Provide hard copy documentation for distribution to each field test site.
- Resolve all reported documentation problems.
- Participate the selection Beta Test sites.

Customer Services System Engineering (CSSE)

- Ensure Field Service support for each test site, if applicable.
- Institute any field test training needed to prepare Field Service to support the product being tested.
- Coordinate reports on ease of installability.
- Participate the selection Beta Test sites.

Field Test Support

- Size/complexity of product/system under test as well as the Engineering Group will determine whether the Corporate Field Test Administration office is used to coordinate the tests or some other designated personnel.

Field Test Support Person

- Be the primary contact between Digital and the test sites.
- Provide status of the test sites as determined by the Field Test Team.
- Coordinates problem reporting and resolution.
- Responsible for obtaining signed license agreement.
- Participate in the selection of Beta Test sites.
- Distribute proper field test materials to the test sites.
- Request the destruction or return of all field test materials after the test is over from each site.

Corporate Field Test Administration Office

- See their formal charter.

Qualification Team

- Evaluate plan for product performance, human factors, and reliability goals.
- Analyze field test data.

Reports

- Periodic reports based on customer polling and on activities during the test.
- Unit status - hardware and firmware (in other words, ECO status, firmware revision level).
- Final report at the end of testing period.
- See heading 2 for reporting and record retention requirements.

Reporting

Performing a product qualification is only half the job. The results must be clearly documented for use by manufacturing, customer services, sales, and other support organizations. At times functional, operational, and even legal problems arise in the course of designing, manufacturing and selling a product that require the ability to "go back" and understand what testing was done on a product and what the results were. Without clear, easy-to-read and easy-to-find qualification test results, that task becomes almost impossible. Therefore, the following steps should be completed:

- Results should be written in a concise executive summary format, with details available as appendices for those requesting them.
- Results should be published in memo form after each group of related tests or phase of testing. For ORT, test results shall be reported monthly as a minimum.
- Memos relating to interim results should be collected and appended to the final report. For DVT this should also include the results of Digital standard testing, regulatory agency approvals, operating system certification, and field test results.
- The memos and final report shall be published and archived with the documentation and law departments within Digital. Contact Corporate Records Management and the Law Department for guidance.

10 PRODUCT CHANGE QUALIFICATION

Value Engineering projects of a mature or established product result in varying amounts of change to the product's design, manufacturing process and materials. These partial changes require a unique qualification process that is different from the needs of a new product, yet more complex than a single ECO. The Qualification team must determine the complexity of the proposed changes to design the appropriate level of qualification testing required. The more risk taken with the proposed change, the more testing to be done in order to lower the risk to the product. The Qualification team must determine the impact of changes to components, materials, processes, layout or technology and then design the testing that best minimizes the risk of the changes to the product.

10.1 PLANNING/QUALIFICATION TEAMS

The planning team is made up of individuals representing functional areas that are affected by the change. This team is responsible for addressing the functional impact to their area as well as resource planning for the qualification effort. The main purpose in having this team–which can be considered an extended qualification team–is to address all the problems, concerns, and resources up front, especially in the areas needing specialized, expert input, such as safety and regulatory testing.

The planning team is comprised of the following.

- VE project leader
- VE design engineering
- Reliability/quality
- Systems engineering
- Safety
- CSSE
- Environmental testing
- Original design engineering

The Qualification Team is responsible for developing the test strategy and plans, and for implementing and monitoring all testing performed as part of the qualification. The chairman is responsible for overseeing and managing the entire test to guarantee effective results. This includes the following.

- Managing the planning, analysis, and corrective actions for problems encountered.
- Establishing effective controls to ensure adherence to the plans.
- Reporting to management of risk assessment.

The Qualification Team is comprised of the following.

- VE design engineering
- CSSE
- Reliability/Quality
- Manufacturing

NOTE

The Qualification Team is a subset of the planning team. It is strongly recommended that individuals on the qualification team be from the original Phase 0 planning team.

10.2 QUALIFICATION PROCESS

Establish Product and Program Requirements

In this phase, the product and program requirements are established. These include, but are not limited to, cost savings, schedule, volumes, and reliability. The VE project leader identifies and secures support from representatives of the planning team, as defined in subhead 2.5.1. The project leader is responsible for producing a qualification input document, based on inputs from the planning team. That document should contain the following.

- Project definition and goals.
- Recommendations and inputs to project from planning team members.
- Action plans and commitments from the functional groups (that is, safety, reliability, system engineering, environmental) for required support; in other words, environmental lab time and resources safety testing lab time. The group should remain intact until the document is complete.

Qualification Planning

During this planning phase, a new design base line is established. From this new base line, cost, schedule, and functionality impact can be determined. The design group is responsible for providing an updated product specification and other preliminary documentation that defines the changes made (that is, topographical, technology, materials, packaging, process, cooling, and so forth). In this phase, the Qualification Team must meet and determine the complexity of the proposed changes to design the appropriate level of qualification testing required. This phase is complete when a qualification plan has been written and approved.

Implementation

During this phase, the product is designed and prototypes are produced. The VE project leader assures that the functional, safety/regulatory, and environmental testing is done according to the plan. Testing was defined according to the complexity of change, and it may range in the functionality area from a simple lab evaluation to a full DVT; in the safety area from evaluating changes on paper to full DEC STD 119 testing; or in the environmental area from a local lab test to full DEC STD 102 testing.

When functionality, safety/regulatory, and/or environmental regulations are not affected by the change, no testing is required (or defined in the plan).

Qualification

During this phase, the design and process reliability and system performance is assessed. The VE project leader assures that the reliability and system performance testing is done according to the plan. Testing is defined according to the complexity of the change and may range in the reliability area from a paper analysis of impact to a full reliability demonstration on both the design and process; or in the system performance area from evaluating the change in one unit to network and/or cluster testing.

In the event that reliability and/or system performance are not affected by the change, no testing is required (or defined in the plan).

11 BUYOUT QUALIFICATION PROCESS STRATEGY

This subhead of the Digital Qualification Process Manual deals with issues unique to the qualification of buyout-type products.

The purpose is to provide a process for qualifying Digital products that are, or contain, buyout-type products. The process includes basic strategies, and Digital-and Supplier-related issues that affect the final qualification process.

This process applies to all organizations within Digital responsible for hardware and software products for sale to Digital's customers that are, or contain, buyout-type products.

Buyout-type products are any products or part of a product (with the exception of components; that is, resistors, ICs, capacitors, and so forth) specified and purchased by Digital that is designed and/or manufactured by a non-Digital supplier.

There are three classes of buyouts: fully-customized, semi-customized, and off-the-shelf.

- A fully-customized buyout is designed and manufactured by a non-Digital supplier exclusively for Digital.
- A semi-customized buyout is the supplier's standard design modified and manufactured for Digital. It is a non-standard product for the supplier, and it may encompass changes to form, fit, function, and finish.
- An off-the-shelf buyout is the supplier's standard product, involving no changes to functionality. It may encompass changes for cosmetic purposes ONLY, such as logo, and other "trade dress."

The process for qualifying Digital products that are, or contain, a buyout should be the same as the process for qualifying a Digital designed and manufactured product.

However, the qualification process of a buyout-type product does differ from that of a Digital designed and manufactured one, due to the class of buyout and various Digital Supplier constraints. Non-Digital suppliers have standards and cultures that differ from Digital's. Digital has a responsibility to make clear its qualification requirements to the vendor, but must allow the vendor the freedom to choose the techniques. The qualification process that follows will achieve a high level of product quality provided that Digital works with each supplier to define a qualification process in mutually-understood terms. This agreed-to qualification process must be embodied in the Basic Order Agreement (BOA).

11.1 FACTORS TO CONSIDER IN ASSESSING LEVELS OF RISK FOR BUYOUT PRODUCTS

The qualification of a buyout can be complex, involving many variables. The ability of the supplier, and of Digital, to support the program must be weighed carefully.

Following are some of the more important criteria, and pitfalls, to be considered when designing the qualification plan of a buyout.

11.2 SUPPLIER-RELATED ISSUES

Skills and Resources

The following supplier assessments should be addressed prior to establishing a basic qualification strategy.

- A thorough evaluation of the supplier's overall resources, specifically the following.
  - — Design Engineering.
  - — Personnel skills and experience levels in the area of Test Engineering.
  - — Quality Engineering.
  - — Reliability Engineering.
- Basic knowledge of reliability techniques and processes.

- Organizational evidence of reliability engineering skills and resources, and previous experience with conducting qualification testing of the type Digital would expect them to conduct.

  These would indicate the supplier's ability to fully understand Digital's expectations, as well as how to perform the tests, including physical resources such as the amount of test, environmental, and laboratory equipment.

- Their degree of process and product maturity, and their general overall breadth of experience and knowledge, would also determine how much of the testing they could perform.

  Any unique processes or technology should be considered from the standpoint of Digital having the skills or knowledge to fully support the testing.

- The geographic location of the supplier could affect Digital's ability to support, and may very well dictate the location of the qualification.

- A detailed understanding of the differences between the supplier's and Digital's standards and methods of qualification will be required to develop and adequate Qualification program, and to determine who will perform what tests and where they will be done.

  It will be necessary to know the supplier's ability, and willingness, to test to Digital's standards.

- Their overall manufacturing capability, and degree of vertical integration of their process, will indicate their ability to support the program and provide adequate preproduction build requirements for test units.

Supplier Reputation

In addition to all of the above considerations, special attention should be paid to the overall degree of cooperation, the extent of prior involvement (if any), willingness to conform to Digital's unique program requirements, flexibility, or, in general, the ease of doing business with them. This is one of the most important factors that will contribute to the success of the program.

Existing Supplier Product Base

General reputation and perceptions in the market place, and size of installed base, are key indicators to be considered. Product performance and field history—such as field data, failure data, reliability data, quality data—are all valuable information that can be used to corroborate with previous data and test results.

11.3 DIGITAL-RELATED ISSUES

TIME-TO-MARKET

Time-to-market considerations may dictate a test strategy. It may require that Digital and the supplier perform portions of the testing in parallel to expedite the process, or Digital could decide to perform qualification in lieu of the supplier.

Volume and Life of Product

Consideration should be given to the ramp-up rate, and total volume of product over the expected life. however, equal consideration must be given to short-term financial risk/gain to digital versus possible long-term customer satisfaction implications.

Technical Aspects

The degree of sophistication of the product technology and systemness–that is, networking, communications capability, regulatory requirements, conformance to standards, and complexity of functionality–will also determine the technical risk to digital and the level of testing required.

Digital Value Added Design and Processes

The degree of confidentiality of design, or uniqueness of digital process and technology, will drive qualification strategy. Such items as proprietary firmware, bus specifications, or Digital manufactured and supplied LSI devices may determine how much information can be supplied to the supplier for him to adequately qualify the product.

11.4 BASIC QUALIFICATION STRATEGIES

There are four basic approaches to the qualification process that fit most buyout situations.

The underlying criteria of any test of qualification program is to ensure that product requirements are met with a high degree of confidence, and that shipments start on time.

Even though the basic design evaluation may be performed by the Supplier, Digital is still responsible to assure and manage the process. Digital's responsibilities are basically the following.

- Helping the Supplier understand their responsibilities.
- Auditing the Supplier's efforts.
- Manage the overall qualification process.
- Verifying that the total design works as planned in a systems environment.

Supplier Performs Qualification

This strategy relies on the expertise, knowledge, and resources of the supplier to perform the qualification. It places that responsibility and ownership of the design problems and corrective action at the source. It offers the opportunity for the supplier to evaluate both product and process. This is the preferred strategy.

Use Existing Supplier Test or Field Data

This approach is used when the product is mature, or when extensive qualification testing was already completed and documented. Conceivably, the product is debugged and mature, therefore the need for additional Digital qualification testing may not exist.

The factors that influence this test strategy are the following.

- The supplier's standard product satisfies Digital requirements.
- A large installed base exists, with adequate field performance data available, and the likelihood of a high Digital field exposure is minimal.

Qualification Jointly Shared by the Supplier and Digital

This approach is used when there may be some joint design effort by the Supplier and Digital, or when resource or time restraints dictate. Digital may be incorporating the buyout into a larger systems configuration, and complete testing can only be done in the final system. The proportion of this shared responsibility can vary significantly depending on the program needs.

Qualification Performed by Digital

This strategy may come into play if the uniqueness of use or design, program schedules, or the capabilities of the Supplier dictate that this approach be taken. When this happens, it becomes very important for Digital to have a strong partnership with the supplier to expedite corrective action.

11.5 THE BUYOUT QUALIFICATION PROCESS

Following is a generic process for qualifying buyout products.

Intent

To follow the intent of the Digital Qualification Process, and to ensure that the finished Digital product will be indiscernible by the end-user from a standard in-house product.

Prerequisites

- The BOA has been signed, which establishes a legally binding business relationship between Digital and the Supplier.
- The Product Qualification Team has been defined and is in place to assist in bringing the program from Supplier Negotiations through Digital Certification.
- All specification's are under change (PCO/ECO) control.
  - — Purchasing Specification (Product Functional Spec)
  - — Drawings, Schematics, and other related documents
- The Qualification Team has agreed to start the Test Process.

Product Qualification

The basic design evaluation normally belongs to the Supplier. Digital is responsible for the verification of the total design, even if the Supplier is actually performing much of the testing. A Buyout test Strategy entails the following.

- Maximizing the Supplier's test/qualification effort (concentrating Digital's efforts on auditing the Suppliers test).
- Conducting those test the Supplier does not have the capacity or capability to perform.
- Verifying a Supplier product in a Digital system.

Field Test/System Test

This test process demonstrates that the product satisfies the requirements of the engineering specification and of the customer's expectations through testing in selective customer environments.

- Alpha Field Test - Verifies the product specification and is conducted internally in Digital.

- Beta Field Test - Verifies the customer's expectations in a real customer's environment.
- Refer to Schedule 1. Typical Buyout Qualification Schedule for timing of these test events.
- System test where applicable:
  - — Verify System functionality.
  - — Verify Operating System functionality.

Process Verification

The basic process design and evaluation belongs to the Supplier. However, Digital is responsible for the Verification of the total Process Qualification Program. The following is a summary of key Manufacturing Process events.

Manufacturing System Assessment (MSA): A-SP-7665326-00-0

- This process is an assessment of the Suppliers process and support systems.
- Its purpose is to evaluate the Suppliers ability to meet program goals.
- A preliminary Manufacturing System Assessment (MSA) is conducted prior to the award of a contract by Digital. A final MSA is conducted prior to the start of Process Qualification.

Manufacturing Readiness Review (MRR)

The Manufacturing Readiness Review (MRR) process is intended to evaluate the Supplier's production readiness to meet program requirements (material availability, tooling, test equipment, process equipment, manpower, training, and so forth), and the Supplier's ability to meet volume capacity plans.

- MRR is an optional process, highly recommended, at the discretion of the Program Management Team. If conducted, it's recommended that it happen at least on month prior to start of Process Qualification.
- A MRR should be conducted at the Supplier's facility.

Process Verification Testing (PVT)

This test demonstrates that the manufacturing process is qualified to produce a product that meets its functional specification and can meet the reliability requirements as defined in the engineering specification. The requirements for this test are the following.

- The intent of heading 2 will be met.
- This test will be conducted at the Supplier's facility.
- The overall Suppliers manufacturing process in place as determined by the Program Management Team.
- The supplier writes this plan, and it is reviewed and approved by the Program Qualification Team.

On-going Reliability Test (ORT)

This test process monitors residual infancy and measures product reliability within its useful life.

- The intent of the Digital Standard ORT Process, as outlined under subhead 2.2.8, will be met.
- This test will be conducted at the Supplier's facility.
- The Supplier will report data/results to Digital on an agreed-upon basis.
- The Supplier writes the plan, which is reviewed and approved by the Product Qualification Team.

Product/User Audit

This process is a customer-level inspection and functional test conducted on a sampling basis.

- This test is performed at the Supplier's facility and is conducted prior to or after the packaging operations, before it becomes finished goods.
- The Supplier writes the plan which is reviewed and approved by the Product Qualification Team.
- The Supplier will report data/results to Digital on an agreed-upon basis and frequency.
- A continuous sampling plan is recommended.
- Implemented with the first Process Qualification unit by Supplier Quality Control (QC) personnel.

11.6 APPLICABLE DIGITAL STANDARDS

Following is a minimum list of Digital Standards that apply to the qualification of new buyout products. Others may apply, depending upon the nature of the product.

The vendor's standards (if any exist) should be checked against the appropriate Digital Standards. When differences occur, the strongest requirements should be used.

There are Digital Standards that must be met by Digital because of Corporate responsibilities and liabilities. These standards are the following:

- *DEC STD 103-0 Electromagnetic Compatibility (EMC) Hardware Design Requirements*
- *DEC STD 104-0 Product Acoustic Noise Acceptability*
- *DEC STD 119 Digital Product Safety (all sections)*
- *DEC STD 178 Digital Marking Requirements (all sections)*

Responsibilities

The new product Qualification Team is responsible for ensuring that a new product's qualification plan includes a complete list of all the Digital Standards to which the new product must conform. This team is also responsible for ensuring that the organizations which will perform the conformance testing provide the necessary plans and schedules, as input to the new product's overall qualification plan.

11.7 SPECIFIC TEST RESPONSIBILITY

A viable Buyout test strategy entails maximizing the Supplier's test qualifications effort while concentrating Digital's efforts on auditing the Supplier's tests and conducting those tests the Supplier does not have the capacity or capability to perform. The results of such an approach are as follows.

- Using the Supplier's test results, as much as possible
- Eliminating redundant testing
- Reducing time to market

Table 1 identifies some of the test and verification requirements that a Buyout undergoes, and how the test responsibility is split.

Table 1: Specific Test Responsibility

Supplier	Either	DEC
Base Design Verification (DVT)	Reliability Qualification	DVT (All or Selected)
Dec-Unique Design Verification	Diagnostic & Software Validation	System Evaluation Software & Hardware Compatibility (Verification with current & new products/software releases)
Process Verification Test (PVT)	Environmental/Product Safety DEC STDs 102 and 122	DVT:
DEC STDs 060 and 119		FCC System Test
Product Safety		Acoustics
ORT		VDE/GS
Product (User) Audit		Field Test:
		Alpha/Beta
		POM (SOQT)
		MSA
		MRR

12 LIFE TESTING

Life test is NOT a gate to FRS.

Life Testing evaluates product performance over extended periods of time, typically years. The reasons for this testing is as follows.

- Identify time dependent failure mechanisms so they can be corrected on existing products as well as future products.
- Use failure data to:
  - — Create/enhance component data bases–both electrical and mechanical
  - — More accurately model and predict future product reliability.
- Provide accurate failure data in a timely manner.

Life Testing is applicable to any product because it is focused on understanding failure rates with respect to time. However, the main focus should be on products that exhibit wear-out, i.e., the failure rate sharply increases relative to time. Examples of this are products that

contain mechanical or electromechanical components that are known to have a limited useful life.

12.1 IMPLEMENTATION

Life Testing is implemented in two parts, the first part being at or toward the end of the Reliability Qualification Test (RQT). Typically, all or a portion of the RQT sample is used for the Life Test sample. The product is continued to be stressed both within and to the product specification limits for an extended period of time. In the case of mechanical devices, the product goes through a "tear-down" at predetermined intervals to identify any wear characteristics that may lead to failure. The second portion of Life Testing is performed on periodic samples from Manufacturing. The test methodology is the same as for the units from RQT so that correlation can be done on an on-going basis between original product/vendors and current product/vendors.

The generation of the specific Life Test plan is the responsibility of the Qualification Team. The test should be established at the prime manufacturing plant and run under the control and funding of that plant's manufacturing quality organization.

12.2 LIFE TEST PLAN

Specific Life Test plans should include but not be limited to the following:

- Prerequisites
- Sample sizes
- Methods of test; that is, hardware configuration, software to be run
- Test environment
- Acceleration factors (where applicable)
- Periodic teardown intervals, if applicable
- Failure analysis
- Reporting
- Responsibilities

APPENDIX A

REFERENCED DOCUMENTS

A.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-00002-00	*DEC STD 002-0 AC Power Wiring, Safety Earth Grounding, Plugs and Receptacle Information and Requirements*
EL-00005-00	*DEC STD 005-0 Operational Alert (OPAL) Procedure*
EL-00005-01	*DEC STD 005-1 In-Plant Product Hold Procedure*
EL-00005-02	*DEC STD 005-2 Reporting Products Potentially Non-Compliant with Digital Design Standards*
EL-00009-01	*DEC STD 009-1 Product Engineering Specifications: Electrical, Physical, and Environmental Parameters*
EL-00009-02	*DEC STD 009-2 Product Engineering Specifications: Requirements for Specifying Reliability Parameters*
EL-00028-00	*DEC STD 028-0 Phase Review Policy*
EL-00030-00	*DEC STD 030-0 Module Manufacturing Standard*
EL-00032-00	*DEC STD 032-0 VAX Architecture Standard*
EL-00038-00	*DEC STD 038-0 Systems Evaluation of New Products - General*
EL-00038-01	*DEC STD 038-1 Systems Evaluation of New Products - Software*
EL-00038-02	*DEC STD 038-2 Systems Evaluation of New Products - Hardware*
EL-00052-00	*DEC STD 052-0 Operational Requirements for Serial Terminals and Computer Interfaces Operating as DTEs Connected to EIA RS-232-C or CCITT V.28 Modems - Definitions and Terminology*
EL-00052-01	*DEC STD 052-1 Operational Requirements for Serial Terminals and Serial System Interfaces Operating as DTEs Connected to EIA RS-232-C or CCITT V.28 Modems*
EL-00052-02	*DEC STD 052-2 Electrical Requirements for Binary Interfaces That Conform to EIA RS-232-C or CCITT V.28 Modems*
EL-00052-03	*DEC STD 052-3 Automatic Calling and/or Answering Equipment on the GSTN Using the 100 Series Interchange Circuits*
EL-00052-04	*DEC STD 052-4 Local Direct Connection (No Modem) for Serial Asynchronous Terminals and System Interfaces*
EL-00053-00	*DEC STD 053-0 Interface Between Data Circuit-Terminating Equipment and the Public Switched Telephone Network (PSTN) in the U.S. and Canada*
EL-00057-00	*DEC STD 057-0 VAXBI Standard*
EL-00060-00	*DEC STD 060-0 Design of Hardware Products to National and International Regulations and Standards, Policies and Responsibilities*
EL-00060-01	*DEC STD 060-1 Design and Certification of Hardware Products to National and International Regulations and Standards - Specific Requirements*
EL-00062-00	*DEC STD 062-0 Product Submittal to Regulatory Agencies*
EL-00066-02	*DEC STD 066-2 Waivers to Digital Design Standards*

EL-Class Number	Document Title
EL-00102-00	*DEC STD 102-0 Environmental Standard for Computers and Peripherals - General Test Requirements*
EL-00102-01	*DEC STD 102-1 Environmental Standard for Computers and Peripherals - Temperature, Humidity, and Altitude Test Requirements*
EL-00102-02	*DEC STD 102-2 Environmental Standard for Computers and Peripherals - Mechanical Shock and Vibration Test Requirements*
EL-00102-03	*DEC STD 102-3 Physical Stability Requirements During Shipping and Handling*
EL-00102-04	*DEC STD 102-4 Environmental Standard for Computers and Peripherals - Product Acoustic Noise Measurement*
EL-00103-00	*DEC STD 103-0 Electromagnetic Compatibility (EMC) Hardware Design Requirements*
EL-00104-00	*DEC STD 104-0 Product Acoustic Noise Acceptability*
EL-00119-00	*DEC STD 119-0 Digital Product Safety - Introduction and General Requirements*
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